Main Group Chemistry
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Lecture – 24
Chemistry of Group 2 elements

Welcome to MSB lecture series on main group chemistry. In my previous lecture I was discussing about the utility of magnesium oxide as refractory material. Today let me continue and discussing the utility of main group elements and their compounds. Let me first consider calcium chloride. Calcium chloride is used in cold countries for de-icing and dust control to maintain very effective de-icing at temperature as low as 222 Kelvin or minus 51 degree centigrade one can use conveniently calcium chloride.

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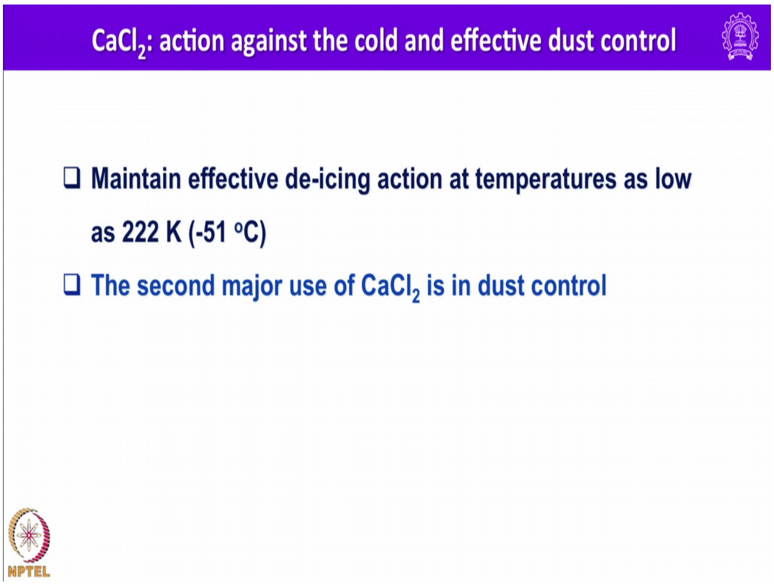

Also the other important use of calcium chloride is in dust control. In cold countries approximately especially in United States of America and Canada approximately 30 percent of the calcium chloride manufactured is used for de-icing of roads and public walkways and sometime it is also mixed with the small quantity of sodium chloride.

Anhydrous calcium chloride takes of water in an exothermic manner. The heat evolved during hydration melts surrounding ice and is sufficient to maintain effective de-icing option at temperature as low as minus 51 degree centigrade. In the second major application of calcium chloride is in a dust control. Again this application relies on the ability of anhydrous calcium chloride to absorb water this time from atmosphere. So, addition of anhydrous calcium chloride to dry road surfaces and hard (Refer Time: 02:07) provides a means of tracking water helping to aggregate the dust particles. So, now, let us look into other utilities.

Let us consider gypsum plasters. In fact, gypsum has a long history the earliest known use of gypsum plaster was in Anatolia that is a part of Turkey and Syria in about 6000 BC and in about 3700 BC Egyptians used gypsum plaster inside the pyramids. At present the building industry is the major consumer of gypsum plaster and gypsum is nothing, but calcium sulphate to H 2 O it is mind on a large scale worldwide and it is calcium to form beta hemihydrate; that means, essentially when you take calcium sulphate to H 2 O that is gypsum and if we heat it to 150 degree centigrade it forms a hemihydrate having half equivalent of water. So, that is gypsum.

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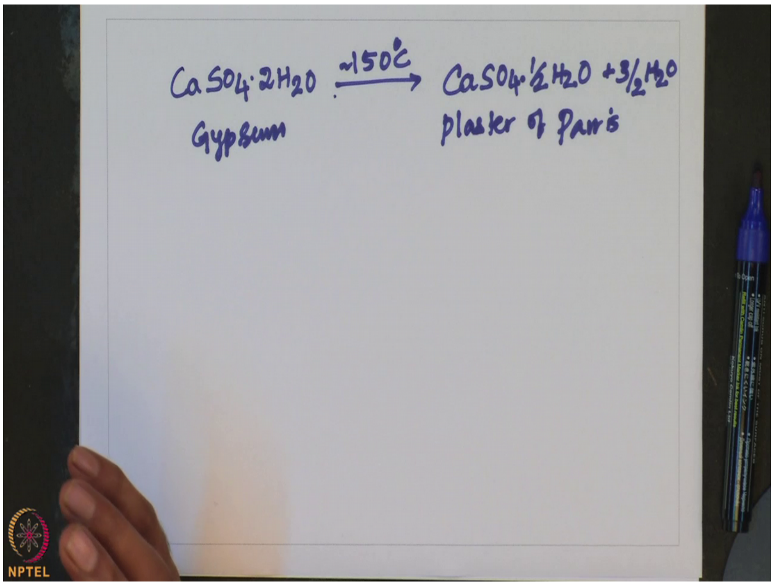

So, here this gives, of course, plus 3 by 2 water comes out. So, this is called plaster of Paris. So, hydration of the hemihydrate with a carefully controlled amount of water initially gives slurry which hardness as calcium sulphate to H 2 O again; that means, you this one has a affinity for taking water to go back to gypsum form. So, this is what is being exploit in making a slurry and moulding it to required shape. Crystals are needle like and it is there inner growth or intergrowth that provides gypsum with its strength and suitability for the building trade calcined gypsum which is stored for the rehydration process so; that means, calcined gypsum the plaster of Paris it has to be kept away from moisture as it is highly hygroscopic.

The setting process of gypsum plaster may be accelerated or slow down by a suitable additive. So, in this case essentially one can add up to 0.1 percent of citric acid that is sufficient to retard the crystallization process as slow down the crystallization process. Gypsum plasters suitable for applying to was have been developed so that additives are already present with the hemihydrate. So, building contractors commonly use free fabricated gypsum plaster boats and tiles and plaster boards are fabricated by pouring a hemihydrate water additive slurry onto cardboard sheets of approximately 0.5 mm thickness after completing the lamination by applying a second sheet of cardboard the plasterboard is dried and it can be used for further application in residential construction and other aspects.

The incorporation of fiberglass into plaster boards is also possible giving fiber board products and advantage of gypsum plaster boards as partition walls is essentially due to their very effective 5 resistance.

In 2000, 108 megatons of gypsum was produced worldwide and it was almost 1000 metric ton in 2016 that indicates the extensive use of this plaster boards in construction within the US itself in 2000, 22.9 metric tons of free fabricated gypsum products were sold are used.

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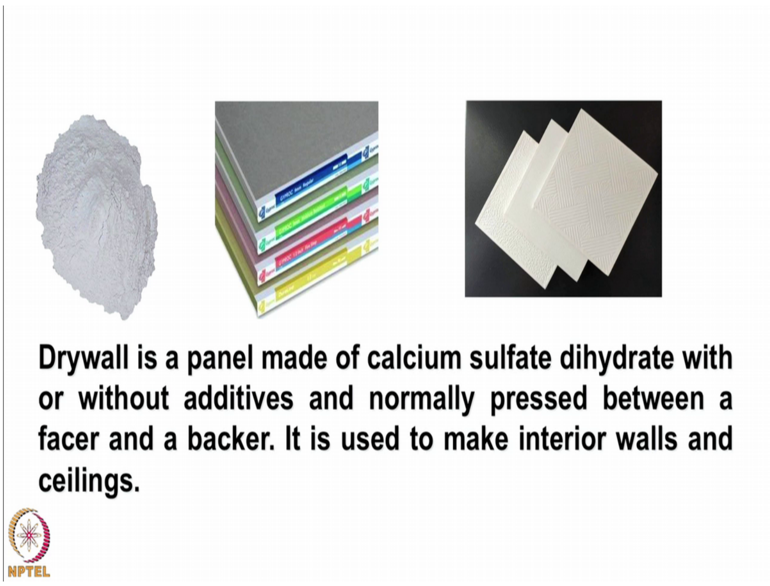

And this is how plaster of Paris that is calcium sulphate hemihydrate looks like and from this one with proper methodology one can make into small tiles or one can also make sheets of this type and they can be used as partition walls. The major utility of this one comes because of their resistance for temperature and of course, besides this many of this group 2 elements and their compounds are used as agents for drying or predrying solvents organic solvents drying agents that react irreversibly with water.

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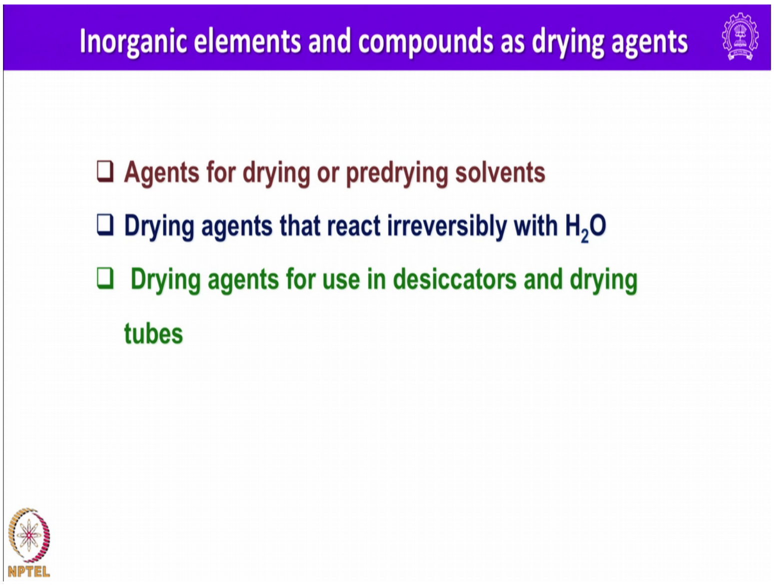

Drying agents for using desiccators and trying tubes; that means, here we come across 2 types of drying agents. Some of them react reversibly with water and some of them react irreversibly with water and those which are reacting reversibly with water can be used in desiccators and drying tubes so that we can reuse them after removal of water by heat into higher temperature.

Let us look into both drying and predrying solvents. Typically anhydrous salts that absorb water as solvent or suitable for removing water from solvents in organic solvents, if I have moisture is there in order to distill and make pure anhydrous dry solvents one has to use some of this water absorbing materials are drying agents. So, here this comes very handy. Anhydrous salt such as magnesium sulfate, calcium chloride, calcium sulfate, sodium sulphate and potassium carbonate are hygroscopic. So, among this calcium sulphate and magnesium sulfate are particularly efficient and can be used as inert drying agents and drying agents that react irreversibly with water are for example, calcium hydride and as such sodium lithium aluminium hydride. So, you cannot recover them because they react with water to give some other product.

Already you know what is going to happen when you treat calcium with water or calcium hydride with water if trace amount of moisture is there conveniently sodium or calcium can be used. Sodium essentially used as a wire is extremely efficient because of larger surface for removal of water from hydrocarbons or ethers. But reacts with for example, alcohols and certainly it is not suitable for drying halogenated organic solvents one should not use in drying halogenated or chlorinated organic solvents.

So, some of the compounds are also used as drying agents indicators and drying tubes which are calcium chloride, calcium sulphate, potassium hydroxide and phosphorus pentoxide. Gases may be dried by a passage of the gas to be purified are dried though drying tubes packed with some of these reagents in the form of pallets, but possible reaction with the gas with the drying agent must be considered. So, when you have passes some gas for drying we should ensure that the gas which is reacting with any of this should not be used. So, then there we have to use some other drying agents.

Although P 2 O 5 phosphorus pentoxide is a common size for using desiccators reaction with water results in the formation of a brown viscous layer on the surface of anhydrous power that essentially curtains its dehydrating ability. And also sometime what happens it because of this thick layer of viscous moss that is generated insert still active P 2 O 5 is there one has to be extremely careful while disposing because P 2 O 5 can volunteer react with water to form phosphoric acid. I would be giving you more details while discussing chemistry of group 15 elements.

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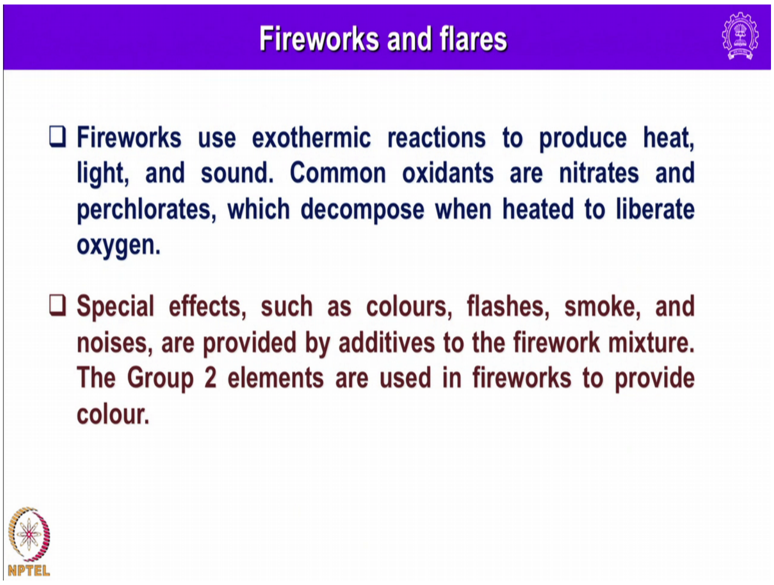

Of course, in firework and flares alkaline earth metals are used and fireworks use exothermic reactions to produce heat light and sound.

Common oxidants are nitrates and perchlorates which essentially decompose when heating to liberate oxygen. Special effects such as colour, splashes, smoke and noises are provided by additives to the firework mixture. The group 2 elements are used in fireworks to provide colour we know they give characteristic colour. Barium compounds are added to fire works to produce green flames, apple green flames.

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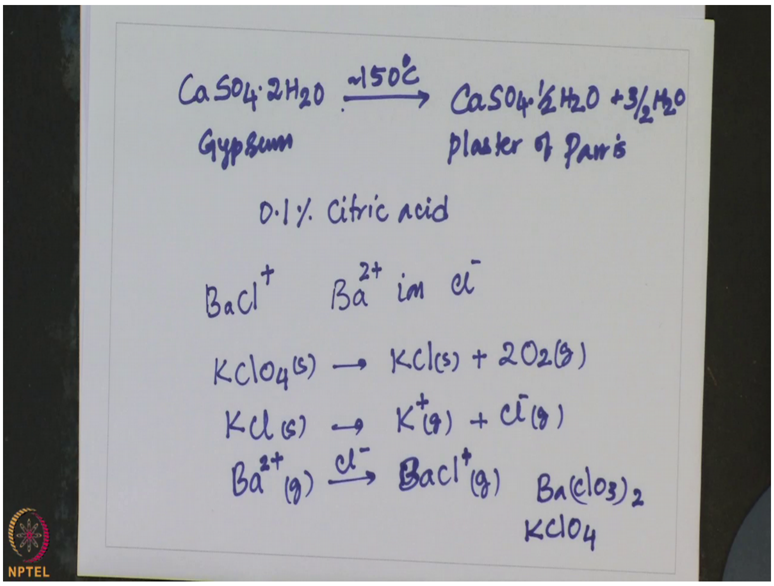

The species responsible for the colour is essentially BaCl plus which is produced when Ba 2 plus ion combines with Cl minus the Cl minus ions are produced during decomposition of perchlorate oxidant or during combustion of the PVC fuel polyvinyl chloride fuel. So, here KClo 4 solid gives KCl plus 2 O 2 and KCl gives k plus plus Cl minus Ba 2 plus gives plus Cl minus gives BaCl minus BaCl plus and also in some cases barium chloride is also used barium chloride is BaCl O 3 2 minus in place of potassium perchlorate. So, this is say about the application of alkaline earth metals in fireworks.

Similarly strontium nitrate and carbonate or used to produce red colour on formation of strontium. If you want to give red colour one should be used strontium and essential here and similar to that one barium chloride. So, it forms strontium chloride plus strontium chlorate and per chlorate are effective in producing red colour.

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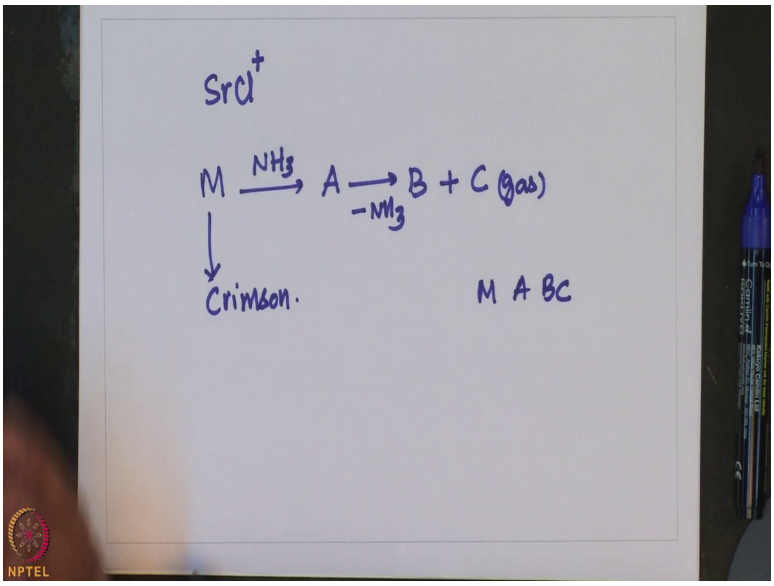

Magnesium is also added to firework and place to maximize the light output since magnesium produce an intense white light illumination is increased by the incantations of high temperature, magnesium oxide particles producing the oxidation reaction; that means, here whatever the oxen that is produced in an exothermic reaction can react with magnesium to form a magnesium oxide and that is also highly exothermic that gives white light.

So, let us into some questions on main group elements and their compounds. I have given a question here you can read it. A group 2 metal M dissolves in liquid ammonia a group 2 metal M dissolves in liquid ammonia to form a compound A, A slowly decomposes to B with the liberation of NH 3 plus C gas and metal M gives crimson flame test if you do flame test it gives crimson colour. So, now, suggest identify M A B and C. Let me read out the question again a group 2 metal M dissolves in liquid ammonia and from the solution compound a can be isolated a slowly decomposes to B with liberation of NH 3 and a gas C metal M gives a crimson flame test through blue glass the flame appears pale purple suggest identities for M A B and C; that means, find out M A B and C.

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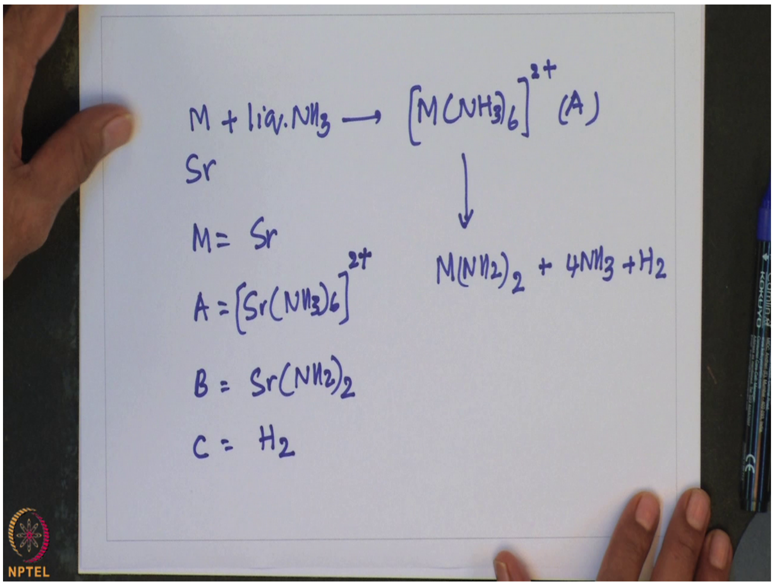

So, let us solve this one it is a very simple question of course, by looking into the flame test one should be able to tell what it is. First let us write M. So, when you put ammonia liquid ammonia it should form because this is from group 2. So, this let us considered this as A, so A slowly decomposes to B plus ammonia plus gas comes. So, here it is M NH 2 twice plus 4 NH 3 and plus H 2. So, here this is similar to sodium amide NaNh 2 here (Refer Time: 16:39, M NH 2 plus 2 will come.

So, here of course, flame test clearly indicates that this is strontium. So, M is strontium and this is the complex, complex will be A is hexamine strontium complex 2 plus 2 plus and then B is this amide complex neutral compound because NH 2 minus is there and C is; obviously, hydrogen. So, there is the answer for this question.

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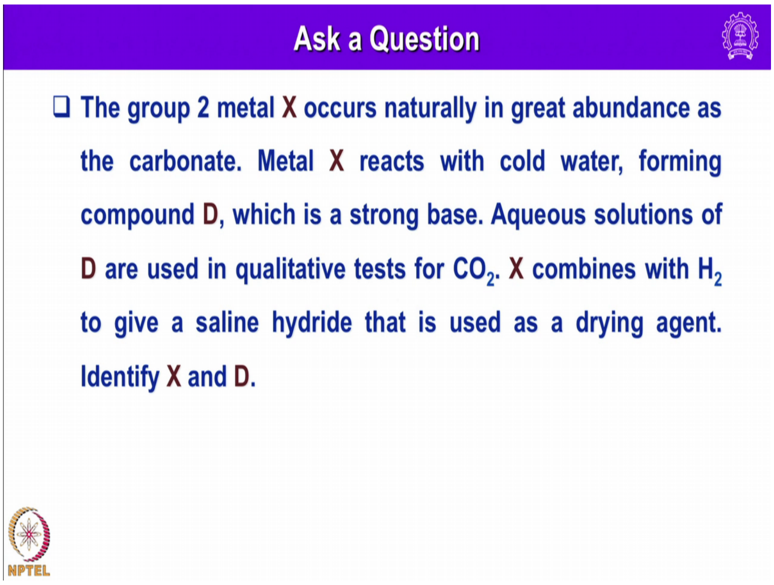

There is one more question very similar one group 2 metal occurs groups 2 metal X occurs naturally in great abundance as the carbonate. Metal X reacts with cold water forming compound D, which is a strong base aqueous solution of D is used in qualitative test for carbon dioxide X combines with hydrogen to give a saline hydrate that is used as a drying agent. So, identify X and D we should find out what is the X what is the group 2 metal and what is D.

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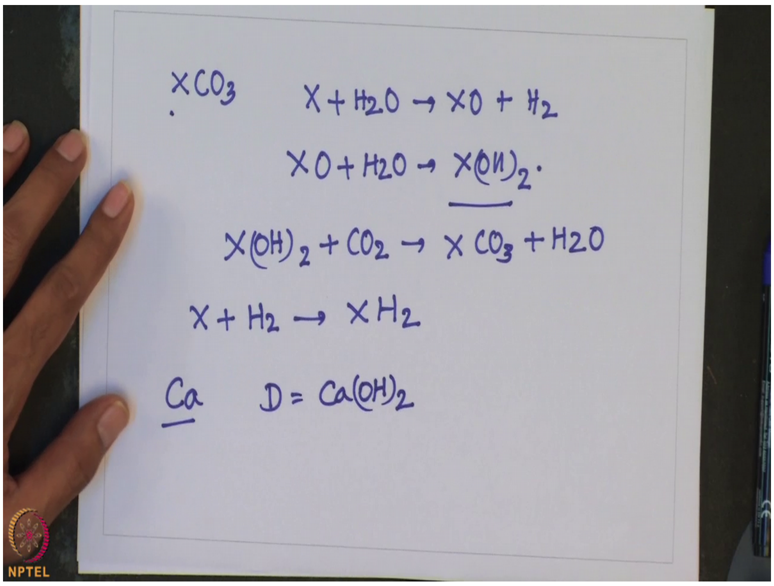

So, let us consider this is XCO 3, we have to find out what is X it is an alkali metal. So, X plus H 2 O initially gives XO plus H 2 and of course, XO with another molecule of water it forms hydroxide and this hydroxide reacts with CO 2 to gives XCO 3 back plus H 2 O. So, X plus H 2 gives XH 2. So, it is completed now; obviously, this is X is calcium here X is calcium and D is this one, D calcium hydroxide. So, this is the answer for this question.

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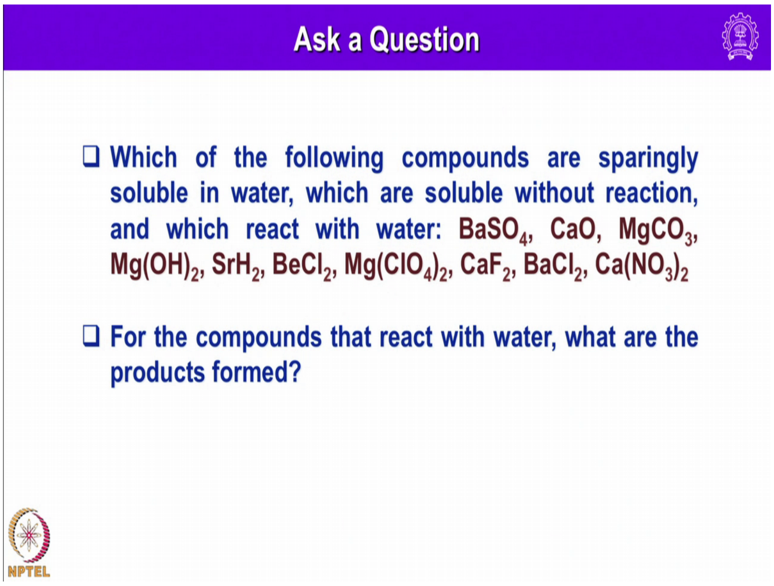

So, let us look into couple of more questions here. I have given a list of alkaline earth metal salts various salts which of the following compounds are sparingly soluble in water which are soluble without reaction and which react with water barium sulphate, calcium oxide, magnesium carbonate, magnesium hydroxide, strontium hydride, barium chloride, magnesium perchlorate, calcium fluoride, barium chloride and calcium nitrate.

The next one is for the compounds that react with water what are the products formed. If at all if the reacting with water you have to write the product; that means, using a balanced chemical equation represent that one the interaction of those salts with water.

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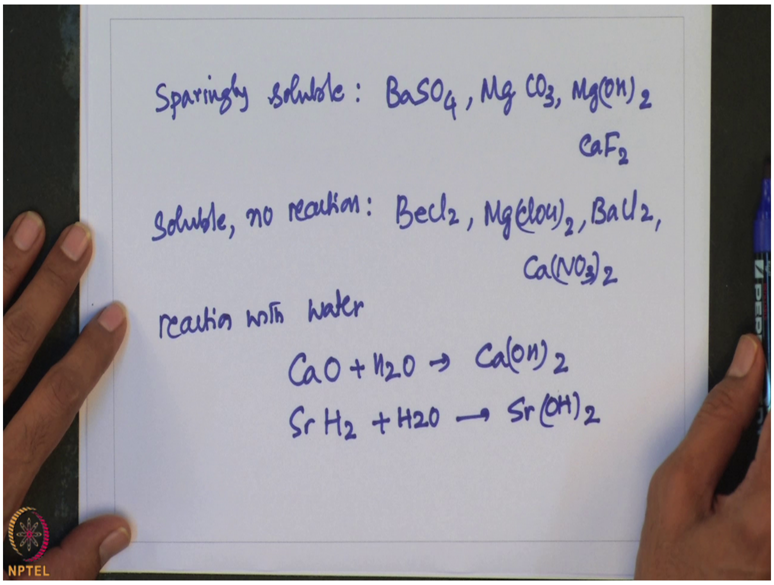

So, here one can simply say sparingly soluble or insoluble ones are, sparingly soluble ones are essentially heavier alkaline earth metal salts BaSO 4, magnesium carbonate, magnesium hydroxide and calcium fluoride. Soluble no reaction some of them are soluble, but they do not react there is simply ion ice are they form aqua compound coordination compounds are BaCl 2. So, it forms hexa, so this forms Belgium forms cater aqua compound magnesium as performed cater aqua compound barium chloride is insoluble this is also forms and similarly calcium nitrate. They form the corresponding aqua complexes in these cases we will get hexa aqua compounds and those which react with water calcium oxide of course, when calcium oxide reacts with water the product expected is calcium hydroxide and strontium hydride when reacts with water it gives strontium hydroxide as well. So, essentially one can answer in this fashion.

Look into couple of more questions I have given here.

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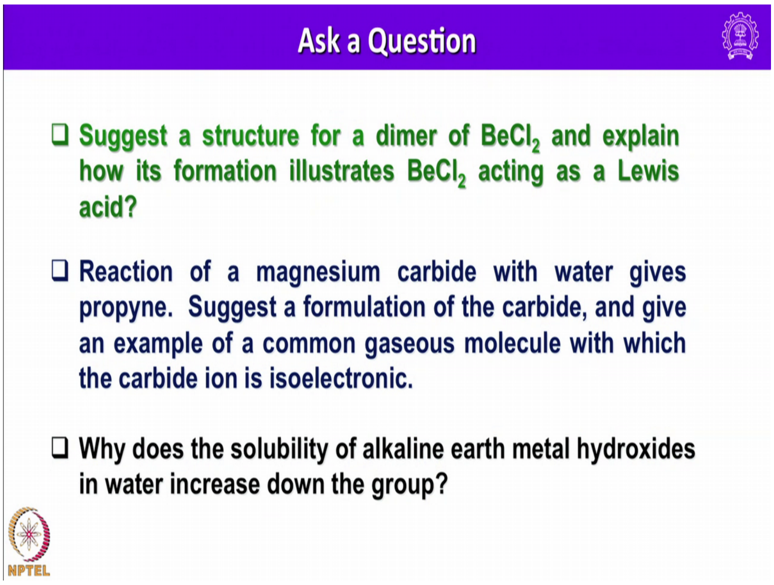

Suggested structure for a dimer of beryllium chloride and explain how its formation illustrates beryllium chloride acting as a lewis acid. I had already expand this one while discussing beryllium hydride structure. It has a one has to polymeric structure prior to the formation of BaCl 2 what it does is it promotes one of the electron to the p orbital and undergoes sp 3 hybridization to form 4 sp 3 hybrid orbitals with 2 sp 3 hybrid orbitals having one electrons each. There will be 2 sp 3 having no electron.

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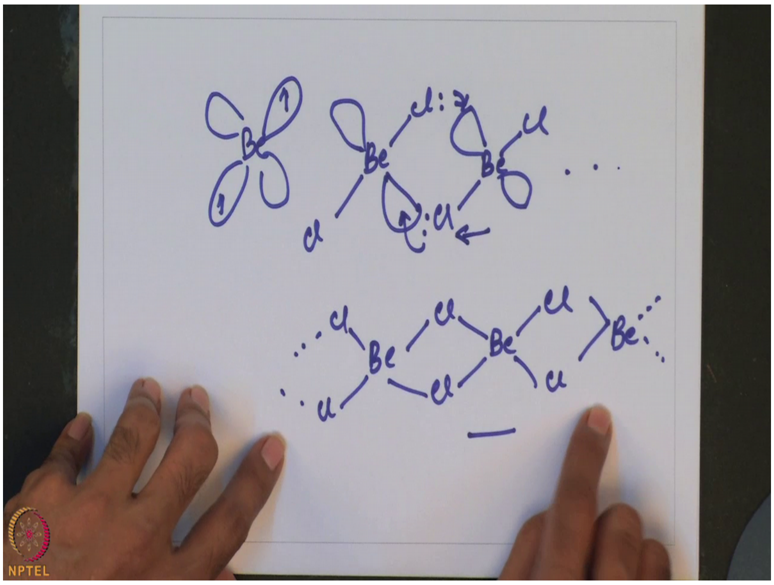

Simply one I will show here like this one electron here and he 2 no electron and this will combine with chlorine p s 2 p 5. So, it forms now cl, Cl and now we have empty once, and another one comes here it arranges in this fashion it continues like this. So, here now this lone pair is giving donated here. So, it forms now, it continuous like this. So, it continuous like this.

So, now, basically what happens this one if you consider this portion it acts as a Lewis base and this is electron deficient this access Lewis acid; that means, there is a mutual one portion that this one BaCl bond access Lewis base whereas, B with sp 3 having no electron access Lewis base and, through this process what we get is one dimensional chain like structure.

So, there is one more question here. Reaction of a magnesium carbide with water gives propyne. Suggest a formulation of the carbide and give an example of a common gaseous molecule with which the carbide ion is isoelectronic. That means, a magnesium carbide with water gives propyne, so the formation of propyne indicates that the carbide should have 3 carbon atoms. So, that is the clue you get it once you have a clue simply balance the charts and write considered a suitable composition so that means, if it is give propyne they should be C 3 and in all to balance this one, one should go for this one Mg 2 C 3. So, that you can also write it and see whether this is balanced or not.

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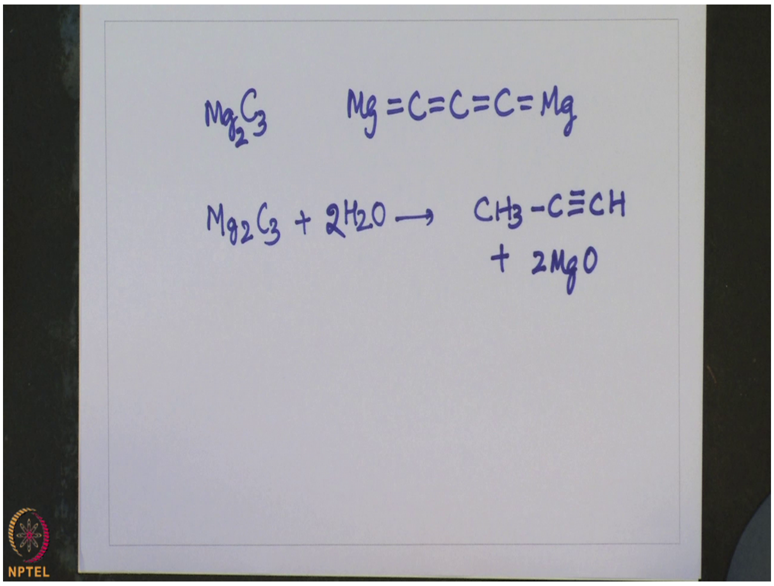

So, now, if you see the valency of all of them are balanced this 2 plus 2 this 2 plus all are 4 minus. So, it is taken care. So, now, let me write like this here Mg 2 C 3 plus water. So, when water is added here one can get a compound like CH 3 C CH. So, this is taken care with 2 (Refer Time: 25:26) of water and then plus 2 Mg O, yes. So, this is the answer for this one. So, that is, what we get is one propyne, answer is one propyne.

So, why does the solubility of alkaline earth metal hydroxides in water increases down the group? The size of anions being much larger compared to cations the size of anions being much larger compared to cations, the lattice enthalpy will remain almost constant within a particular group since the hydration enthalpies decrease down the group solubility will decrease as phone for alkaline earth metal carbonates and sulphates. But in case of hydroxides it is a different thing happens among alkaline earth metal hydroxides, the anion being common the cationic radius will influence the lattice enthalpy since lattice enthalpy decreases much more than the hydration enthalpy with increasing ion size obviously, the solubility increases as we go down the group.

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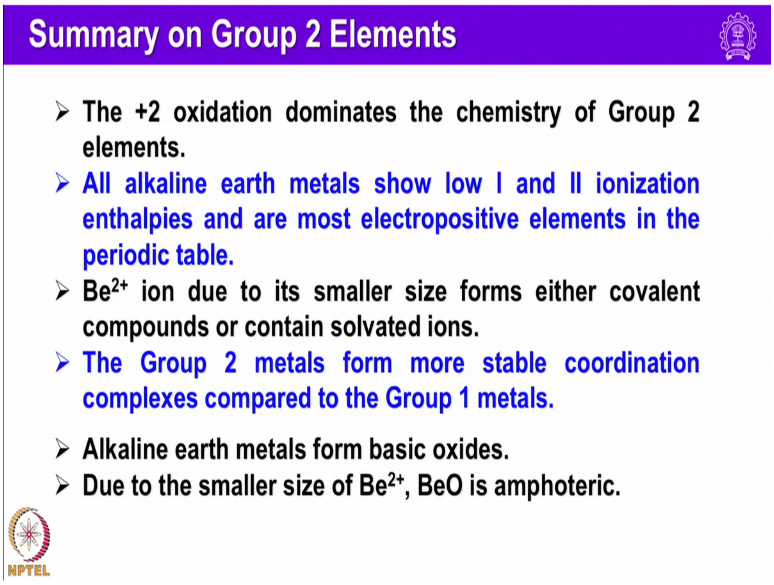

So, let me summarize the chemistry of group 2 elements and plus 2 oxidation dominates among group 2 elements or alkaline earth metals show low first and second ionization enthalpies, but the relatively more compared to group one alkali metals and are most electropositive elements in the periodic table. Beryllium 2 plus ion due to its smaller size and large charge to size ratio form either covalent compounds are contain solvated ions and its chemistry is little different from the rest of the elements in group 2. Group 2 metals form more stable coordination complexes compare to the group one metals and alkaline earth metals form basic oxide similar to alkali metals. Due to the smaller size of beryllium 2 plus beryllium oxide is amphoteric and it behaves more or less very similar to aluminium oxide.

So, with this I complete the chemistry of group 2 elements. In my next lecture I will be discussing about the chemistry of p block elements to begin with I will consider group 13 elements. Until then have a present reading of inorganic chemistry.

Thank you very much.